CHIPPING NORTON LAKE AUTHORITY

RESTORATION OF LIVERPOOL WEIR

MAY, 1980

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LAURIE, MONTGOMERIE & PETTIT PTY. LTD.
CONSULTING ENGINEERS & SURVEYORS

PWD 80009
# CHIPPING NORTON LAKE AUTHORITY

## REPORT ON
PROPOSED RESTORATION OF LIVERPOOL WEIR

## CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>2. HISTORY OF THE WEIR</td>
<td>2</td>
</tr>
<tr>
<td>3. HISTORICAL VALUE OF THE WEIR</td>
<td>3</td>
</tr>
<tr>
<td>4. PRESENT CONDITION OF THE WEIR</td>
<td>5</td>
</tr>
<tr>
<td>5. PROPOSED STRUCTURAL PROTECTION</td>
<td>7</td>
</tr>
<tr>
<td>6. RESTORATION OF THE WEIR</td>
<td></td>
</tr>
<tr>
<td>6.1 General</td>
<td>9</td>
</tr>
<tr>
<td>6.2 The Downstream Wall</td>
<td>10</td>
</tr>
<tr>
<td>6.3 Removal of the Road</td>
<td>10</td>
</tr>
<tr>
<td>6.4 Rebuilding of the Crest</td>
<td>11</td>
</tr>
<tr>
<td>7. ESTIMATE OF COST OF RESTORATION</td>
<td>11</td>
</tr>
</tbody>
</table>

## FIGURES

- **Figure 1** Liverpool Weir Restoration Works
- **Figure 2** Protection for Liverpool Weir, Scheme 2
- **Figure 3** Protection for Liverpool Weir Typical Sections
1. **SUMMARY**

By letter dated 3 September 1979, the Chipping Norton Lake Authority commissioned Laurie, Montgomerie and Pettit Pty. Ltd. to report on:

a) alternative methods of protection for Liverpool Weir against effects caused by future changes in the river;

b) restoration of the weir.

The first part of this brief has been the subject of a preliminary report to the Authority. This report is confined to recommendations for the weir's restoration.

For purposes of this report, restoration is defined as the works proposed to present the weir in a manner as near as is reasonably practicable to its appearance as constructed last century. The restoration works are thus separate from the measures required to ensure the long-term structural stability of the weir.

The original weir was constructed in 1836 under the supervision of David Lennox to provide a water supply for the town of Liverpool. Although the weir is a very simple structure of no particular engineering merit it is one of the few remaining structures built by Lennox and was essential to the early development of Liverpool. Because of these factors, the weir is of some historical significance and has been recognised as such by the National Trust and the Australian Heritage Commission.

Because of past reconstruction needed to repair flood damage, very little of Lennox's original weir remains intact. However, the part that still remains, i.e. the curved downstream sill of sandstone blocks, is the most outstanding visual feature of the weir.
There is no question of being able to make a completely authentic restoration because Lennox's original work has been modified so extensively by others. The works to stabilise the weir structurally have been considered in relation to restoration works as defined above and the proposals herein have been developed to eliminate latter day incongruities and preserve the overall character of the weir.

The estimated cost of the restoration is $70,000. However, this is only a preliminary estimate and the final cost will depend upon the condition of the fill in the main body of the weir and the resolution of some uncertainties associated with the works.

2. HISTORY OF THE WEIR

Liverpool Weir was originally conceived as a scheme to supply water to Liverpool. The Engineer, David Lennox, was instructed in August 1835 to prepare an estimate for a dam a little below the General Hospital, but he considered this site to be unsuitable and suggested a site a little distance upstream where the width was 120 feet and the water shallower. He reported that a dam could be erected here by driving a row of piles across the stream backed by puddled clay at a cost of 100 pounds, if done by prison labour, or 350 pounds by contract.

However, on further consideration he proposed a much more comprehensive scheme which, if carried out, would supply the whole district with fresh water. This proposal was for a masonry dam, to serve also as a roadway, some 11 miles lower down the river at the quarry from which the stone for Lansdowne Bridge had been obtained, at which point the stream was enclosed by rocky banks. This proposal included the installation of a lock and swivel bridge and was estimated to cost not more than 400 pounds. This proposal was blocked by the Governor who eventually approved of an alternate suggestion by Lennox for a dam faced with masonry at the Town of Liverpool, the existing site.
The 'Sydney Morning Herald' of February 1, 1836, reported the commencement of construction of the weir. The weir was constructed under the supervision of Captain W. H. Christie of the 80th Regiment who was then the Assistant Engineer and Superintendent of Ironed Gangs in the Town of Liverpool. The original construction was probably finished about August 1836 as it was inspected in that month by Captain Barney, the Commanding Royal Engineer and pronounced satisfactory.

The weir did not retain its original form for very long. Repairs to flood damage and extensions over the years have resulted in the curved downstream sill of sandstone block and some limited areas of sandstone block paving being the only visible sections of the original weir. In 1903 a Mr. A. Peake wrote the following on the construction of the weir:

"The dam was built in three periods. The first structure consisted of two parallel masonry walls, the space between being filled with ballast and silt, through which the water can pass freely. The top was pitched with freestone blocks, many of which have been removed and replaced with concrete. At a second period, an addition on the upper side of the dam was made by driving two rows of sheet piling 12 feet apart and filling in with inferior puddle for a depth of 5 feet. In 1860, a flood cut a channel round the south end of the dam and carried out the alluvial bank. As the dam formed the only causeway (at this time) across the river, it was necessary to extend the dam across the new channel, a further addition of two rows of sheet piling was also made on the high side of the structure, between the rows of piling good clay pug was rammed, and this was decked over on the weir and pitched along the roadway. The third portion of the dam has been since repaired, the Liverpool Municipal Council and the Minister contributing each 100 pounds."

3. HISTORICAL VALUE OF THE WEIR

Historically, the weir is significant in that it provided the original water supply for the Town of Liverpool and is one of the few surviving examples of the work of David Lennox, Australia's first major bridge builder.
The weir no longer serves its original purposes but it still functions as a tidal and saltwater barrier. The riverine ecology upstream of the weir has no doubt long since adapted to a freshwater regime.

In 1976, the National Trust of Australia included the weir in the trust Register with a classified listing. The weir is also on the register of the Commonwealth under its Heritage Act. However, at this date no conservation instrument under the New South Wales Heritage Act, 1977 is in force for the weir.

As an engineering work, the weir has interest but no outstanding merit. It does not compare with some other engineering works of the mid-nineteenth century such as those of George Barney.

4. PRESENT CONDITION OF THE WEIR

The original weir was constructed as a masonry arch. The western abutment was founded on a shale outcrop. The central portion and the eastern abutment were constructed on piles driven through the sand bed to shale. The boreholes drilled by the Department's Soils Laboratory in the central portion of the weir show a fill layer of sandstone rubble and sandy clay fill about 4 metres thick under the top platform. Beneath this fill is the original bed material of coarse sands and gravels that extends to the shale bedrock.

All that remains visible of the original weir is the downstream arch face of sandstone blocks and some sandstone paving on the crest (see Figure 1). The upstream arch face is probably buried beneath the extension that was carried out in the latter part of the nineteenth century.

An underwater inspection of the downstream arch face by the Department in April 1979, revealed that there has been some weathering of the shale foundation of the western abutment, resulting in undermining of the wall.
Sometime before 1876 the weir was extended upstream. This extension could have been carried out in conjunction with the restoration of the weir after the 1860 flood. This flood scoured out the eastern bank and abutment and a causeway was constructed across this break. The downstream face of this causeway has been damaged in subsequent floods. The protection to the downstream face as seen in early photographs appears to have been originally constructed of dumped rip rap.

The repair work that Mr. Peake refers to probably entailed the laying of hand packed stone paving. This paving is visible in photographs taken of the 1974 washout. After the 1978 washout, the slope was paved with concrete.

The scour hole formed after the 1860 flood has provided a stilling basin for water overtopping the causeway. The eastern river bank has been found (the Department’s analysis) to have a very low factor of safety against collapse. However, this bank has remained stable since the 1860 flood.

The original sandstone paving on the crest of the weir has been removed and replaced with concrete paving blocks. The paving has been constructed to the level of the upstream upstand that is visible in the 1876 photograph of the weir. In some areas, this paving has sunk indicating loss of supporting material below.

During the RED scheme, in 1974, the Liverpool City Council started the construction of a piped structure on top of the weir, to provide a dry low flow crossing. This work was abandoned before its completion and still remains in its partially completed state.

The stability of the weir with regard to rotational sliding has been checked by the Department and found generally satisfactory for existing river conditions but the structural integrity of the weir is far from desirable. There are local weaknesses, particularly in regard to the undermining of the foundation area of the downstream face of sandstone blocks.
5. PROPOSED STRUCTURAL PROTECTION

The removal of sections of Epsom Road as part of the Chipping Norton Lakes Scheme and other aspects of the proposed Scheme, will result in changes to the river regime upstream of the lake.

The main consideration in this change in river regime will be the lowering of the tailwater levels below the weir during all flood flow conditions. The lower tailwater results in increased velocities across the weir with more energy being dissipated in a shallower depth of water downstream of the weir. The consequences of this are:

a) Greater scouring of the river bed downstream of the weir. This scouring could cause undermining of the weir and its collapse.

b) Higher velocities across the causeway with an increased chance of washouts occurring.

c) Greater turbulence in the basin below the causeway resulting in scouring of the toe of the eastern river bank and the possibility of collapse of the bank.

These factors which are discussed in detail in a Departmental report of 1978 ("Liverpool Weir Hydraulic Investigations"), have necessitated development of plans for ensuring the structural stability of the weir under the new conditions. Thus consideration of proposals for improving the aesthetic appearance of the weir or reproducing historical authenticity has to be made in the light of the necessary works of structural protection.

Various alternative methods of protecting the weir and surrounding area from the effects described above are presently under study by the Consultant and the Department. The studies are using data obtained from hydraulic model tests, borehole investigation, underwater inspection by a diver and prior office studies carried out by the Department. Details will be covered in a separate report to be submitted to the Authority in the near future.
Figures 2 and 3 show typical details of the protection works proposed. The final scheme has not been selected at this time pending further model tests and studies but any variation to the works shown on Figures 2 and 3 would be confined to the river bed and this would not affect the appearance of the weir or become a factor for consideration in its restoration.

The features of the protection works that have a bearing on the appearance of the structure are the creation of the proposed recreation area and the treatment of the eastern causeway.

The provision of the recreation area, although not an essential part of the protection works, does help to reduce their cost. The toe of the park will have an alignment similar to that of the original river bank when the weir was first constructed. The recreation area will help provide a contrasting visual frame to the downstream arched wall and so enhance the appearance of the latter. The arched wall is the most significant visual feature of the weir.

The eastern causeway will be subjected to high velocity flows and substantial rip rap protection is required. At present this causeway is paved with rough concrete. The paving together with the partly completed concrete causeway presents an unattractive and incongruous appearance. Part of the existing batter will be hidden by the fill for the proposed grassed recreation area and the sandstone rip rap will give the causeway an appearance similar to that when it was first constructed in the 1860's.

The aesthetically-ideal treatment for the paving would be to use dressed sandstone blocks in place of the rip rap. However, this would be an extremely expensive exercise and it has not been considered in the estimate of cost.
6. RESTORATION OF THE WEIR

6.1 General

All that is normally visible (i.e. under dry-weather flow conditions) of David Lennox's original weir is the downstream sill of sandstone blocks and some limited areas of sandstone block paving on the crest at the left and right extremities of the downstream wall (refer Figure 1). This wall and paving are also the only significant visual features of the weir.

Except for the partly built road on the crest and some repair work, the weir has remained unchanged in shape this century. Any restoration can therefore reasonably be confined to maintaining the visible elements of the weir in a sound condition, ensuring that the proposed protection works do not detract from the overall appearance and, as previously mentioned, removing incongruities.

The proposed protection works have been discussed previously in Section 5 and the recommended restoration works for the weir itself are shown on Figure 1. These restoration works mainly consist of:

a) restoration of the downstream face wall at A and E on Figure 1;

b) removal of the partly built road on the left and right sections of the crest (B and C on Figure 1) and the restoration of any damage caused by this construction (and its removal) to the sandstone paving;

c) the rebuilding of sections of the crest where loss of supporting material has resulted in settlement and/or displacement of the crest slabs, (D on Figure 1).

The only section of the weir where work is not proposed is the upstream face of the wall. Except at the left and right extremities the wall is continuously submerged and not exposed to view. The Department's diver found in his inspection that the submerged section of the wall was constructed of concrete and although the aggregate was exposed leaving a rough, pitted surface, it was very hard and quite strongly cemented.
6.2 The Downstream Wall

This wall is constructed of hard durable, hand-cut sandstone blocks. Very little weathering of the blocks has taken place in the past 140 years. However, the shale foundations of the wall have weathered resulting in some undermining. As part of the protection works it is proposed to underpin the wall with concrete. The underpinning will not be exposed to view as it will be continuously submerged.

Areas needing restoration on the wall are at the eastern end where it is in a bad state of repair and where sandstone block have been replaced with concrete.

Some of the blocks on the top course of the wall have been replaced with concrete blocks. As these blocks are somewhat at variance with the rest of the wall, it is recommended that they be replaced with sandstone salvaged from the river bed, if feasible. However, this work, although desirable, is not considered an essential part of the restoration because the weathered concrete blocks do not present such a marked variance to the original sandstone as to appear incongruous.

The eastern end of the wall where it joined the original bank is in a bad state of repair. This point is the junction of the future rock protection for the proposed park and the existing wall. A suitable transition from the stone wall to the dumped rip rap will be required and it is recommended that this be constructed from sandstone from the original weir, salvaged from the downstream river bed. The form of the transition will require careful consideration in the final design.

6.3 Removal of the Road

As the weir stands at present, the partly built concrete road on the eastern and western crest should be demolished for both hydraulic and aesthetic reasons. Implementation of the proposed protection works (refer Section 5) will render the present adverse hydraulic effects innocuous, but the aesthetic objection remains. The cost estimate for restoration therefore provides for removal of this latter-day anomaly, together with restoration of the underlying sandstone paving. Scabbling will probably be required to restore the surface of the sandstone blocks.
6.4 Rebuilding of the Crest

The bulk of the broad crest of the weir is normally under water and coated with algae and mud. Most of the original sandstone capping has been replaced with concrete blocks. However, this concrete is not obviously at variance with the original construction material and close inspection is required in places to differentiate between the sandstone and concrete. The concrete replacement has some historical significance in that it is reported as a maintenance material as early as 1903.

Settlement of capping blocks on the crest indicates that there has been some loss of supporting fill in the body of the weir. However, the protection works in the river bed downstream of the weir will also act as a reverse filter and prevent any further piping.

The presence and extent of any voids in the body of the weir can only be determined by lifting the blocks and inspecting the fill. The ideal time to do this is during the restoration contract when on finding a void, it can immediately be repaired.

7. ESTIMATE OF COST OF RESTORATION

At this stage the estimate of cost for the restoration can only be regarded as tentative. Most of the quantities used are provisional because of the difficulty of actually defining the limits of the work. A closer estimate of final cost will be possible at the final design stage, but it will still be essential to frame the contract document so that the nature of all operations and possible contingencies arising are fully specified.

Much of the work is labour intensive and although highly skilled labour is not required the work must be carefully carried out. Good supervision and control will be essential and this will bear on the selection of the contractor for the work. The latter should desirably have some competence in handling stonework in a situation such as this.

The estimated cost of $70,000 has been based on a number of assumptions and provisional quantities. The main assumptions are listed below:
a) The work will form part of the same contract as the protection work. This allows better utilisation of plant, especially lifting gear. It also means that the Contractor's establishment and de-mobilisation costs can be assumed to be covered in the main structural works. Major contingencies, such as disruption of work by floods, will be provided for in the estimate for the protection work. For the restoration work only a relatively modest contingency sum has been allowed, intended to apply only to the particular work items involved in restoration.

b) About 100 cubic metres of sandstone blocks can be recovered from the river bed and surrounding areas for use in the restoration of the eastern end of the weir.

c) The lifting of the slabs in the crest would be carried out in three stages. In each stage one third of the crest is cofferdammed off with sandbags. It was assumed that only 10% of the crest paving would require lifting and repair work, but it is very probable that in so doing an equivalent quantity would become dislodged and would also require to be lifted and reset. Allowance has also been made for supplying 20 square metres of new concrete paving blocks to replace any that are now damaged or are damaged during lifting.

The work required in repairing the crest is the most difficult to estimate. Full investigation prior to restoration would not be warranted because of the cost. The quantities assumed are in accordance with the previous assumptions but the final quantities could vary depending on the conditions found when the paving is removed. A very unfavourable situation could add an additional $10,000 to the cost.
## ESTIMATED COST OF RESTORATION

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<th>Unit</th>
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SANDSTONE BLOCK PAVING  
(ORIGINAL WEIR 1836)

LIVERPOOL STATION

WESTERN (LEFT) BANK

PIERS OF OLD RAILWAY BRIDGE

EXISTING ROAD SECTION  
(R.G.S. 1874)

CONCRETE BLOCK PAVING

CREST  
(USUALLY UNDER WATER)

DOWNSTREAM FACE  
(USUALLY UNDER WATER)

UPSTREAM FACE  
(AS REBUILT LATER IN 19TH CENTURY)

EXISTING ROAD SECTION  
(R.G.S. 1974)

EASTERN (RIGHT) BANK

CABLE MAKERS PROPERTY

EXISTING ROUGH CONCRETE PAVING  
FOLLOWING 1978 FLOOD DAMAGE

EXISTING ROUGH CONCRETE PAVING  
FOLLOWING 1978 FLOOD DAMAGE

REMNANTS OF RUBBLE RETAINING WALL

PROPOSED ROCK PROTECTION TO  
RECREATION AREA

REMANTS OF RUBBLE RETAINING WALL

PROPOSED ROCK PROTECTION TO  
RECREATION AREA

NOTE:
A. CONCRETE BLOCKS IN WALL TO BE REPLACED WITH SANDSTONE BLOCKS.
B,C EXISTING CONCRETE ROAD SECTION TO BE DEMOLISHED AND ORIGINAL PAVING SURFACE RESTORED.
D. SUNKEN AND DISPLACED PAVING BLOCKS TO BE LIFTED AND RELAID ON PREPARED FOUNDATION.
E. RESTORATION OF EASTERN END OF WALL TO FORM TRANSITION FROM VERTICAL UPSTREAM FACE TO PROPOSED ROCK PROTECTION OF RECREATION AREA.

LIVERPOOL WEIR PROPOSED RESTORATION WORKS
FIGURE 1
PROBABLE FUTURE SCOUR HOLE (-3 to -7m)

EXISTING CONCRETE RAMP AND PIPE STRUCTURE TO BE REMOVED. (NOT SHOWN)

SCALE: 0 10 20 30 40 50 60 70 80 metres

PROTECTION FOR LIVERPOOL WEIR
SCHEME 2
FIGURE 2
PROTECTION FOR LIVERPOOL WEIR
TYPICAL SECTIONS
FIGURE 3